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SECOND QUARTERLY PRIMPERS REPORT

CA-(IM-44./5 Moderate Precision Giana Smalened Crystal Units 1 July - 30 September 1962

Contract Busher BA-3 100 31 30-819-7

Placed By.

UNITED STATES ARM STOPAL STREET STREET PHILADELPHIA, HENRY WAS

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CR-(ZM-44)/U Moderate Precision Glass Enclosed Crystal Units

SECOND QUARTERLY PROGRESS REPORT COVERING PERIOD 1 JULY - 30 SEPTEMBER 1962

The object of this study is to establish capability to manufacture moderate precision crystal units in the HC-27/U (glass) crystal holder.

Contract Number DA-36-039-SC-86717 Signal Corps Specification SCS-120 (9 Nov. 1961)

Prepared by:

Howard E. Dillon and

John G. Deininger

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MIDLAND MANUFACTURING COMPANY

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ABSTRACT

Construction of glass-holder sealing equipmen: is under way.

Tentative quartz resonator designs have been partially evaluated, and appear to be satisfactory.

PURPOSE

This program is simed at establishing a production source capable of mass producing a semi-precision quarts crystal unit in in an evacuated glass holder. The significance of glass and vacuum on long term reliability and aging characteristics has been proven in previous Signal Corps R & D. Contracts.

when attempting to menufacture a newl-precision crystal unit, several items sust be considered and respiraised in the light of generally tighter performence noterances. This respiraisal generally leads to tightening of manufacturing or arrels and tolerances. Conventional methods of quarte orientation, saving, dicing, dimensioning, and lapping will be used to obtain a suitable quarte plate. In order to obtain a satisfactory yield, "with a minimum of shrinkage without resorting to screening," a double diffraction X-ray will be used to solect plates within one minute of arc. Tighter congress at X-ray will necessitate tighter telerances in the preliminary orientation and sawing operations

Finish lapping operations, etching, and cleaning processes will of necessity be reviewed and refined as necessary to produce a suitable quarte plate for proper adhesion and stability of the metal electrodes.

The mechanics of soaking the glass, victoret a prequency shift or other damaging after effects, will demand excell study and effort. The importance of the scaling operation as manifold:

Acceptable units will be expected to give an excellent yield through final testing if proper care was exercised in gravia a supplied fabrication. Unacceptable units which while white the fabrication of the holder in order to salvage and rouse quartz plates. It is acticipated that seeting the irequery tolerance at the realing operation will be the most serior problem to evencose.

NATRATIVE AND DATA

Work was continued during the second quarter of the project, on the construction of a sealing tool for HC-27/U holders, and on the evaluation of various quartz resonator designs. Neither task has yet been completed.

Construction of the single head sealing tool was delayed, in part, by several errors in the drawings for the base of the sealing chamber. Because of the need for rework in a shop outside of our plant, a delay of several weeks resulted. Inasmuch as we have never sealed the HC-27/U holder we feel it most important to eliminate the obvious areas of trouble in the beginning; also, very tight deminsional tolerances require more time than usual in the machining of the several parts of the fixutre. An in-plant model shop is nearing completion, and it is expected that machine work and assembly of tooling will progress more rapidly in the future.

Am r-f power generator of 1.0 KVA capacity has been procured from Induction Heating Corporation, Brooklyn, New York, An induction coil, to be used for inducing the heating currents in the metal strip between the glass base and bulb parts of the crystal holder has been designed. A vacuum pump system, with associated valves and controls, has been assembled as part of the glass-scaling tool.

Several lots of overtone quarts resonators have been designed, fabricated, and partially tested. Since the glass-sealing tool has not been completed, the resonators have been mounted in nitrogen-filled EC-6/U holders with tab-clip supports. Measurements of resonant resistance and motional capacitance indicate that the Q requirements will be satisfied without difficulty.

In order to calculate the resonant restance of a capacity of successors in a vacuum from a knowledge of their seathermore and a succession of a miner reference was made to an analysis by Roberts. On erestingly, a miner error was discovered in the analysis, which, where creeked, diver more accurate formula for predicting the offset of simulations. It had, my upon the resonant resistance. Sobera's formula concepts for the viscont loading upon one side of the plate only. One the resistance formula by two. The results of tests on fabricated resonances, together this derivated data, are given in Table I. through V.

Some difficulty has been experienced in the first-plan ingle, as a most used for sample resonators, and appears to have so used to account a consequence of electronic instrumentation. The method which was used to account to here or frequency of the crystal being plated pavolves the conversion to here or the frequency of a special low-drive-level oscilla or robusts led by the crystal being plated. In accordance with conversional stop starting, a frequency meter is supposed to continuously monitor the difference between the frequency of the low-drive-level oscillator and led of a pre-adjustic standard-frequency oscillator. It is said that of a pre-adjustic standard-frequency continuously to the second has not a of the cases, the frequency meter is responding to the second has not a of the caseful tered difference frequency from the miner. The first-partial again meet has been medicied, and the difficult transmed, by lab and was a only while monitoring the crystal frequency sets on one transmit digital frequency counter. A schematic diagram of the low-crystals I oscillator is she to in Pigure I

The RFL IS+330/TSM adaptor has been masked to be one one restant and indications are it will perform to expect to When the cest for

Is used with crystal units requiring regular 3098E drive levels (ad ptor switched out), the test set drive control must be formed nearly full on and the frequency goes upward, in some cases requiring suitching band selector switch to next higher position.

There is also some indication of severe drift of frequency and drive level through an eight hour day. An investigation of these phenomonon revealed low mutual conductance in the 6All6 tube which had no effect on perfermence before installation of the adapter.

Test results on some crystal units fabricated in the higher frequency ranges were unfavorable. Resistances were high and T-C curve turnover point was well below that specified in SCS 120. Additional units, with modifications, have been ordered from saw department. Midland maintains a rough blank inventory at lap, but in the case of the CR-(EM-44)/U, the high angle and thickness requirements are out of line with our general run of crystal units. A change in the orientation angle necessitates going to the saw department and starting with a new stone.

A complete bill of materials for the CR-(XM-44) 'U was not specified by the contracting agency, and none has been established here as yet. The following parts have been procured for evaluation:

Bulb & Base, HC-27/U. 200 pcs. each from Phillips of Canada
Bulb & Base, HC-27/U 25 pcs. each from Masden Co., Inc.

Tab clips, Stainless steel. 500 pcs. from Kay Electronics

Isochemduct 3.5 Epoxy resin cement with \$6 special epoxy hardener (Sample quantity for evaluation)

Pyro-Ceram, #95 high temperature cement from Corning Glass Co.

The mechanics of sealing the glass, without a frequency shift or other damaging after effects, will demand careful study and effort. The importance of the scaling operation is manifold:

Acceptable units will be expected to give an excellent yield through final testing if proper care was exercised in previous steps of fabrication. Unacceptable units, either improper seals or failure to meet electrical specifications, will require destruction of the holder in order to salvage and reuse quartz plates. It is anticipated that seating the frequency tolerance at the sealing operation will be the most serious problem to overcome.

MARRATIVE AND DATA

Work was continued during the second quarter of the project, on the construction of a scaling tool for MC-27/V holders, and on the evaluation of various quarts resonator designs. Neither task has yet been completed.

Construction of the single head scaling tool was delayed, in part, by several errors in the drawings for the base of the scaling chamber. Because of the need for rework in a shop outside of our plant, a delay of several weeks resulted. Inseruch as we have never scaled the HC-27/U holder we feel it most important to eliminate the obvious areas of trouble in the beginning; also, very tight deminsional tolerances require more time than usual in the machining of the several parts of the fixutre. An in-plant model shop is mearing completion, and it is expected that machine work and assembly of tooling will progress uses rapidly in the fature.

An x-f power generator of 1.0 EVA capacity has been procured from Induction Heating Corporation, Brucklyn, New York, An induction coil, to be used for inducing the heating currents in the metal strip between the glass base and bulb parts of the crystal helder has been designed. A vector pump system, with associated valves and controls, has been assembled as part of the glass-scaling tool.

Several late of evertume quarts resemblers have been designed, Sabricated, and partially tested. Since the glass-scaling test has not been completed, the resemblers have been mounted in mitrogen-filled NC-6/8 believe with test-clip supports. Measurements of resemble recistance and motional expenitance indicate that the Q requirements will be satisfied without difficulty.

In order to calculate the resonant resistance of the crystal resonators in a vacuum from a knowledge of their resistance in air or mitrogen, reference was made to an analysis by Roberts. Interestingly, a mimor error was discovered in the analysis, which, when corrected, gives a more accurate formula for predicting the effect of stmospheric loading upon the resonant resistance. Robert's formula accounts for the viscous loading upon one side of the plate only, and his formula is corrected by multiplying the right hand side of the atmosphere resistance formula by two. The results of tests on fabricated resonators, together with design data, are given in Table I. through V.

Some difficulty has been experienced in the finish-plating operation used for sample resonators, and appears to have resulted from inadequate electronic instrumentation. The method which was used to monitor the frequency of the crystal being plated involves the conversion to zero of the frequency of a special low-drive-level oscillator controlled by the crystal being plated. In accordance with conventional shop practice, a frequency meter is supposed to continuously monitor the difference between the frequency of the low-drive-level oscillator and that of a pre-adjusted standard-frequency oscillator. It appears that, in some cases, the frequency meter is responding to the second hammune of the unfiltered difference frequency from the mixer. The finish-plating equipment has been modified, and the difficulty removed, by clating vary slowly while monitoring the crystal frequency with an electronic digital frequency counter. A schematic diagram of the low-drive-level oscillator is shown in Figure I.

The RFL TS-330/TSM adaptor has been installed in one of our test sets and indications are it will perform as expected. When the test set

Is used with crystal units requiring regular 3098B drive levels (adaptor switched out), the test set drive control must be turned nearly full on and the frequency goes upward, in some cases requiring switching band selector switch to next higher position.

There is also some indication of severe drift of frequency and drive level through an eight hour day. An investigation of these phenomonon revealed low mutual conductance in the 6AH6 tube which had no effect on performance before installation of the adapter.

Test results on some crystal units fabricated in the higher frequency ranges were unfavorable. Resistances were high and T-C curve turnover point was well below that specified in SCS 120. Additional units, with modifications, have been ordered from saw department. Midland maintains a rough blank inventory at lap, but in the case of the CR-(KM-44)/U, the high angle and thickness requirements are out of line with our general run of crystal units. A change in the orientation angle necessitates going to the saw department and starting with a new stone.

A complete bill of materials for the CR-(IM-44)/U was not specified by the contracting agency, and none has been established here as yet. The following parts have been procured for evaluation:

Bulb & Rese, HC-27/U. 200 pcs. each from Phillips of Canada
Bulb & Rese, HC-27/U 25 pcs. each from Masden Co., Inc.
Tab clips, Stainless steel. 500 pcs. from Kay Electronics
Leochembuct 3.5 Epoxy resin cament with #6 special epoxy hardener (Sample quantity for evaluation)

Pyro-Ceran, #95 high temperature cement from Corning Glass Co.

*1. Roberts, E.A., Atmospheric Loading Effects on AT crystals.

Semi-annual report, contract DA-36-SC-71061, Union Thermoelectric Corporation, 1 July to 24 December 1956, pp. 38-47.

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Company in 1

Data collected on quartz resonator designs indicate the specification can be set. Greater difficulty, then what was an first empacted, surrounds the construction of the scaling machine.

An extinated 5% of the overall progress has been accomplished in the second quarter.

PROGRAM FOR NEXT INTERVAL

Establish a sealing technique and test seals for conformance to SCS-120. If successful engineering samples will be made and submitted as per contract.

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Howard E Dallion	400 hours
Edward M Roper	56 hours
John G Dainingav	300 hours
Production line netcome	200 hours

₩		LOT NO. L	<u> 24. 1</u>		
e L	PLATE DIA. 0.550	in ELECT	TRODE DIA 0.400	in	ARDE 356 24
		Plono - convex	hevel		
		. Also a secretaring in the forest complete the second of	LOAD CAPACITA		Language of the section
M NO	RESOMANT (Fr) FREQUENCY (mc)	ANTIRESONANT (Fa) FREQUENCY (mc)	RESISTANCE (olum)	Fa-Fr (cps)	STATIC CALVELDANCE (0.5)
	5.008885	5 008913	260	28	4,6
2	5.005123	5.005152	130	29	4.6
1	5.006650	5.006677	100	27	4.6
6	5.007137	5.007164	100	27	4.4
	5_000607	5.008636	16)	25	15.15
<u> </u>	5.002445	5.002473	167	23	4.0
}	5.006768	5.006797	71)	28	4.4
8	5.009080	5.009104	173	24	4.4
9	5.002328	5.002357	193	29	4.4
10	5.009483	5.009511	110	28	4.4
11	5,007076	5.007124	110	28	4.4
12	5.003250	5.003278	160	28	4.4
13	5.003760	5.003789	120	29	4.4
14	5.906757	5.006785	130	28	4.4
15	5.005922	5.005952	18)	36	4.4
16	5.005800	5.005826	100	26	4.4
17	5.002479	5.002507	100	28	4.4
<u>#</u> -	5.006088	5.006119	230	31	4.4
19	5.009363	5.009392	90	29	4.4

	Design and	Per formance	Data	3rd Overto	ne Resonators		
			LOT NO.	H 2 A 3			
į	PLATE DIA	0.550 in	ELECT	RODE DIA.	C.400 in	ANGLE	35° 25'
	CONTOUR 1	2 Diopter	Bi-convex		BEVEL	None	
					LOAD CAPACITA	INCE 50	ȣ

ITEM NO.	RESCHAFT (Fa) FREQUENCY (mc)	ANTIRESONANT (F4) FREQUENCY (me)	RESONANT RESISTANCE (ohm)	Fa - Pr (cp	STATIC CAPACITABCE (pf)
1	7.014565	7.014710	100	145	5. 5
2	7.007703	7.007848	110	145	5.5
3	7.007694	7.007839	120	145	5.5
4	7.015886	7.016032	120	146	5.5
5	7.012408	7.012559	100	151	5.5
6	7.010536	7.010704	180	168	5.5
	7.013073	7.013220	140	147	5.5
8	7.018160	7.018315	100	155	5.5
9	7.009467	7.009614	100	147	5.5
10	7.013203	7.013348	80	145	5.5
11	7.018136	7.018290	90	154	5.5
12	7.016918	7.017070	70	152	5.5
	7.015635	7.015788	120	153	5.5
14	7.015515	7.015669	100	154	5.5
15	7.012728	7.012878	80	150	5.5
16	7.019286	7.019431	140	145	5.5
<i>.</i>					

Design and Performance Data - 3rd Overtone Resonators

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LOT NO. M 2 A 2

PLATE DIA. 0.550in ELECTRODE DIA. 0.370 in ANGLE 35° 25'

CONTOUR 9 Diopter bi-convex BEVEL None

LOAD CAPACITANCE 50 PF

ITEM NO.	RESOMANT (Fr)	1	RESONANT	fa-fr (cpe)	STATIC CAPACITANCE (PE)
	FREQUENCY (mc)	FREQUENCY (nr.)	RESISTANCE (ohm)	Tana (ope)	Cation trunca (be)
1	10.082352	10,082652	30	300	6.9
2	10.087014	10.087307	43	293	6.85
3	10.080278	10.080552	40	274	6.85
4	10.078309	10.078580	30	271	6.7
5	10.075037	10.075320	40	283	6.9
6	10.078706	10.078986	3 5	280	6.85
7	10.081851	10.062136	50	285	6.85
<u> </u>	10.068569	10.068837	19	268	6.7
9	10.082980	10.083257	30	277	6.7
10	10.068006	10.068285	27	279	6.9
11	10.090393	10.090674	24	281	6.85
12	10.057755	10.050025	31	270	6.8
13	10.0612214	10.081499	44	285	6.9
14	10.077651	10.077933	27	282	6.9
15	10.071003	10.071276	27	273	6.8
16	10.004564	10.004045	28	281	6.8
17	10.064856	10.065151	20	295	6.8
C					

Design and Performance Data - 3rd Overtone Resonators

LOT NO. H 2 A 6

PLATE DIA. 0.448 in ELECTRODE DIA. 0.300 in ANGLE 35° 24' 25'

CONTOUR #6 Dicoter bi-convex BEVEL Hone LOAD CAPACITANCE 50 PF ANTIRESCHANT (Fa) RESCHART ITEM NO. Fa-Fr (cps) FREQUENCY (sec) RESTSTANCE (ohm) CAPACITANCE (DE) 15.073540 15.073935 28 395 2 15.043862 15.044224 20 362 6.2 15,021321 15,021728 3.2 407 6.3 15,036466 14 15,036852 386 6.5 5 401 5.2 15,033975 27 15.033574 6 26 15.045349 355 6.3 15.044994 15 372 15.044468 15.044840 6.4 371 6.3 15.034928 15,035299 17 9 15.044298 15.043974 22 324 6.4 10 391 6.2 15.048367 15.048258 20 24 385 6.5 11 15.046990 15.042375 12 15.032071 15.032434 26 363 6.3 15.042538 13 15.042912 18 374 6.3 14 15.039127 15.039521 20 394 6.2 15 15.045223 15.045612 19 389 6.2 15.036742 23 390 16 15.036352 6.3 17 380 15.038630 31 6.3 15.030250

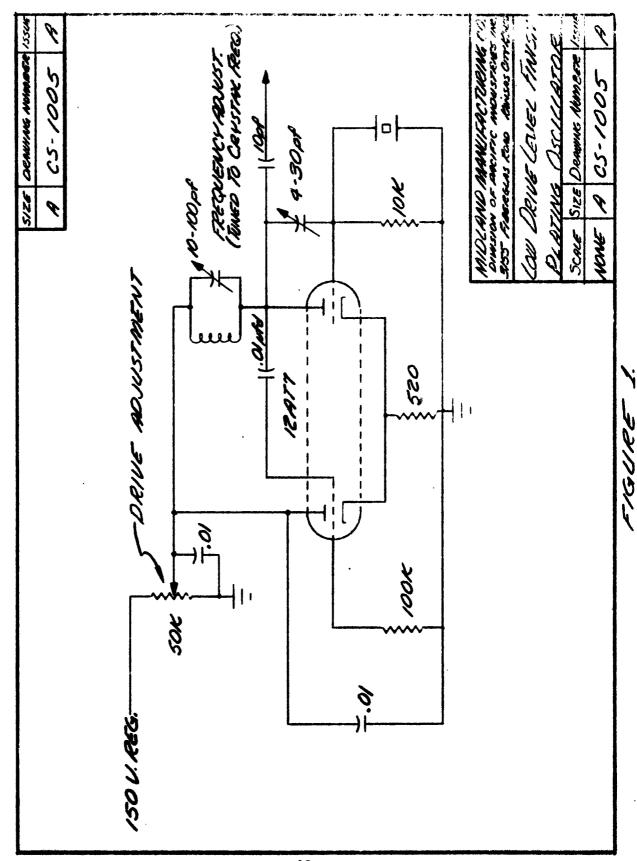
PLATE DIA. 0.448 in RLECTRODE DIA. 0.300 in ANGLE 35° 25' 26' CONTOUR One Micros finish BEVEL None

LOAD CAPACITANCE 50 PF

RESCHART (Fa) FREQUENCY (mc)	AMTIRESQUAMT (Fa) PREQUENCY (me)	RESOLUTE RESISTANCE (ohm)	FA-Fr (cps	STATIC CAPACITANCE (pf)
19.935306	19.935845	19	.539	8.1
19.940332	19.940902	15	570	8.2
19.963927	19.964522	11	595	8.3
19.948767	19.949352	14	590	8.1
19.934024	19.934620	13	546	8.3
19.967955	19.968564	10	609	8.2
19.950621	19.951167	13	546	8_3
19.961384	19.961953	19	569	8.2
19.951077	19.951691	11	609	8.2
19.919377	19.919846	24	469	. 8.1
19.936391	19.936074	14	583	8.1
19.970868	19.971416	15	511 548	8.2
19.945928	19.946465	13	537	8.1
19.975101	19.975698	24	597	8.3
19.92666	19.927222	14	556	8.2
19.930497	19.939055	18	558	8.3
	PREQUENCY (me) 19.935306 19.940332 19.963927 19.948767 19.934024 19.967955 19.950621 19.961384 19.951077 19.919377 19.936391 19.970868 19.975101 19.926666	PREQUENCY (me) PREQUENCY (me) 19.935306 19.935845 19.940332 19.940902 19.963927 19.964522 19.948767 19.949352 19.934024 19.934620 19.967955 19.968564 19.950621 19.951167 19.961384 19.961953 19.951077 19.951691 19.919377 19.919846 19.936391 19.936974 19.970868 19.971416 19.975101 19.975698 19.926666 19.927222	PREQUENCY (mc) PREQUENCY (mc) RESISTANCE (ohm) 19.935306 19.935845 19 19.940332 19.940902 15 19.963927 19.964522 11 19.948767 19.949352 14 19.934024 19.934620 13 19.967955 19.968564 10 19.950621 19.951167 13 19.961384 19.961953 19 19.951077 19.951691 11 19.919377 19.919046 24 19.936391 19.936974 14 19.970868 19.971416 15 19.945928 19.946465 13 19.975101 19.975698 24 19.926666 19.927222 14	PREQUENCY (mc) PREQUENCY (mc) RESISTANCE (ohm) PRESISTANCE (ohm) 19.935306 19.935845 19 539 19.940332 19.940902 15 570 19.963927 19.964522 11 595 19.948767 19.949352 14 590 19.934024 19.934620 13 546 19.967955 19.968564 10 609 19.950621 19.951167 13 546 19.961384 19.951167 13 546 19.951077 19.951691 11 609 19.919377 19.919046 24 469 19.936391 19.936974 14 583 19.970868 19.971416 15 548 19.95101 19.975698 24 597 19.926666 19.927222 1A 556

TABLE V

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